AMRL-TR-77-77

COMPARATIVE ANTHROPOMETRY OF AIR STANDARDIZATION COORDINATING COMMITEE PERSONNEL FOR EQUIPMENT DESIGN: HELMETS

JOHN T. McCONVILLE, PhD

WEBB ASSOCIATES, INC.
YELLOW SPRINGS, OHIO 45387

CHARLES E. CLAUSER

AEROSPACE MEDICAL RESEARCH LABORATORY

NOVEMBER 1977

AEROSPACE MEDICAL RESEARCH LABORATORY
AEROSPACE MEDICAL DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

NOTICES

When US Government drawings, specifications, or other data are used for any purpose other than a definitely related Government procurement operation, the Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Please do not request copies of this report from Aerospace Medical Research Laboratory. Additional copies may be purchased from:

National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161

Federal Government agencies and their contractors registered with Defense Documentation Center should direct requests for copies of this report to:

Defense Documentation Center
Cameron Station
Alexandria, Virginia 22314

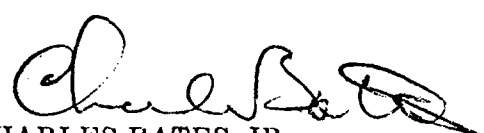
TECHNICAL REVIEW AND APPROVAL

AMRL-TR-77-77

This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER



CHARLES BATES, JR.
Chief
Human Engineering Division
Aerospace Medical Research Laboratory

AIR FORCE/56780/10 February 1978 — 150

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AMRL-TR-77-77	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* COMPARATIVE ANTHROPOMETRY OF AIR STANDARDIZATION COORDINATING COMMITTEE PERSONNEL FOR EQUIPMENT DESIGN: HELMETS		5. TYPE OF REPORT & PERIOD COVERED Technical Report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John T. McConville, PhD Charles E. Clauser, Aerospace Medical Research Laboratory, Wright-Patterson AFB, Ohio		8. CONTRACT OR GRANT NUMBER(s) AF33615-76-C-5007
9. PERFORMING ORGANIZATION NAME AND ADDRESS Webb Associates, Inc. P. O. Box 308 Yellow Springs, Ohio 45387		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62202F, 7184-08-30
11. CONTROLLING OFFICE NAME AND ADDRESS Aerospace Medical Research Laboratory Aerospace Medical Division (AFSC) Wright-Patterson AFB, Ohio 45433		12. REPORT DATE November 1977 13. NUMBER OF PAGES 17
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

anthropometry
helmets
sizing of personal-protective equipment

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The objective of this report is to demonstrate that the comparability of body-size distributions of aircrew personnel of Air Standardization Coordinating Committee (ASCC) member nations is such that protective equipment sized and designed to fit personnel of one member nation will fit personnel of all member nations as well. The research reported on in this publication compares the available anthropometry of the head and face of member ASCC nations, demonstrates their similarities, and tests the theoretical suitability

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

20. ABSTRACT (continued)

of a Royal Aircraft Establishment (RAE) sizing program for helmets to accommodate U. S. Air Force (USAF) personnel.

PREFACE

This study was conducted under Project 7184, "Human Engineering in Advanced Systems," Work Unit 71840830, "Body Size and Mass of Air Force Personnel."

Dr. John T. McConville, Anthropology Research Project, Webb Associates, under contract AF33615-76-C-5007, and Mr. C. E. Clauser, Crew Station Integration Branch, Human Engineering Division, Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio, shared the responsibility for the research.

The authors wish to thank Mr. Thomas Churchill for computer programming support and Ms. Ilse Tebbetts and Ms. Jane Reese, all of Webb Associates, for editing and preparing the manuscript for publication.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

COMPARATIVE ANTHROPOMETRY OF AIR STANDARDIZATION COORDINATING COMMITTEE PERSONNEL FOR EQUIPMENT DESIGN: HELMETS

Objective. The purpose of this study is to demonstrate that the comparability of body-size distributions of aircrew personnel of Air Standardization Coordinating Committee (ASCC) member nations* is such that protective equipment sized and designed to fit personnel of one member nation will fit personnel of all member nations as well. This report compares the available anthropometry of the head and face of member nations, demonstrates their similarities, and tests the theoretical suitability of a Royal Aircraft Establishment (RAE) sizing program for helmets to accommodate U. S. Air Force (USAF) personnel.

The Data Base. The relevant data were assembled and tabulated to obtain an overview of what was available for comparative purposes (Table 1). Although it is apparent that information on a number of useful dimensions for some populations is missing, there are sufficient data to undertake the analysis.

It was found in compiling the results of these surveys that the data varied widely from survey to survey in terms of currency, number of head and face variables and completeness of measuring technique descriptions. The latter is of particular significance since the lack of detailed measurement descriptions or illustrations makes it difficult to determine whether measurements are comparable from one survey to another. In this analysis, measurements were considered to be comparable on the basis of the similarity in variable names although, as will become apparent in the following discussion, this may not be a wholly valid assumption.

Shown on Table 1 are means and standard deviations ( ) for the dimensions of the head and face as well as for each sample's age, height and weight. The single concession made to known differences in measurement techniques is the indication by the letter "p" in front of the numerical value that the measurement for the RAF Head Survey (column 9) was made from standardized photographs of the head, and by the letters "pd" that a value was derived from two such measurements, normally by subtraction.

In Table 2 the USAF 1967 variable means are used as a base for comparison and all other group means shown as deviations from them. (A minus sign indicates a sample mean is smaller than the USAF 1967 mean, and the absence of a sign indicates a positive value.) The delta (Δ) values are in some instances not inconsiderable. Using the variable head circumference, for example, we find the Δ ranging from +0.78 (RAAF Aircrew) to -1.26 centimeters (1965 USAF). As a ratio of the base (USAF 1967) value, this is +1.4% to -2.2% or 3.6% range in Δ's.

---

*ASCC member nations of Working Party 61 include Australia, Canada, England, New Zealand and United States.

TABLE 1

SUMMARY STATISTICS OF SELECTED HEAD DIMENSIONS OF ASCC MILITARY POPULATIONS

	1	2	3	4	5	6	7	8	9	10	11
Variable Name*	1967 USAF n=2420	1965 USAF n=3869	1950 USAF n=4000	1964 USN n=1549	1973 RNZAF n=238	1971 RAAF Aircrew n=385	1971 RAAF Cadets n=97	1971 RAF n=2000	1972 RAF Heads n=500	1962 RCAF n=604	1974 CF n=565
1 Head Circ	57.52 (1.43)	56.26 (1.65)	57.03 (1.53)	57.54 (1.40)	57.65 (1.37)	58.30 (1.50)	57.70 (1.50)	57.67 (1.36)	57.70 (1.37)	57.28 (1.52)	57.75 (1.52)
2 Sagittal Arc	34.64 (1.66)	37.85 (1.53)	38.11 (1.52)	36.91 (2.18)							36.44 (1.98)
3 Min Frontal Arc	13.60 (0.79)	11.97 (0.88)	13.67 (0.96)						13.21 (0.67)		
4 Bit-Coronal Arc	35.76 (1.26)	35.08 (1.39)	35.05 (1.24)	35.52 (1.32)	36.68 (1.28)			35.34 (1.26)	36.13 (1.26)		35.41 (1.36)
5 Bit-Min Front Arc	30.81 (1.00)	30.48 (1.11)	30.48 (1.05)	30.20 (1.08)					31.31 (0.94)		
6 Bit-Subnasal Arc	29.31 (1.02)	28.70 (1.17)	28.98 (1.07)	28.68 (1.06)					29.12 (1.00)		
7 Bit-Menton Arc	32.65 (1.24)	31.41 (1.44)	32.33 (1.23)	32.21 (1.27)					32.40 (1.30)		
8 Bit-Submandibular Arc	30.98 (1.58)	29.29 (1.67)	30.62 (1.54)	31.22 (1.42)					29.78 (1.45)		
9 Bit-Posterior Arc	29.45 (1.49)		29.37 (1.34)	31.44 (2.09)					27.49 (1.13)		
10 Head Length	19.87 (0.67)	19.62 (0.72)	19.70 (0.64)	19.83 (0.66)	19.71 (0.68)			19.90 (0.64)	p**20.53 (0.60)	19.36 (0.78)	
11 Head Diag from Menton	25.60 (0.76)	25.15 (0.86)			25.31 (0.93)			26.21 (0.77)	25.87 (0.78)		
12 Ear Breadth	3.80 (0.30)	3.52 (0.33)	3.66 (0.27)	3.57 (0.33)							
13 Ear Length	6.60 (0.43)	6.34 (0.46)	6.27 (0.41)	6.53 (0.40)							
14 Ear Lgth above Tragion	2.94 (0.29)	2.87 (0.30)	2.97 (0.28)								
15 Head Breadth	15.60 (0.54)	15.31 (0.58)	15.41 (0.51)	15.57 (0.53)	15.21 (0.52)	15.70 (0.50)	15.50 (0.50)	15.78 (0.54)	p 16.34 (0.56)	15.29 (0.59)	
16 Max Frontal Br	11.60 (0.46)	11.46 (0.48)	11.96 (0.50)	12.26 (0.72)					11.19 (0.38)		
17 Bitragion Br	14.25 (0.56)	13.83 (0.65)	14.22 (0.53)	13.99 (0.52)	13.68 (0.62)			13.91 (0.50)	13.76 (0.61)		
18 Face Breadth	14.23 (0.52)	13.99 (0.56)	14.09 (0.50)	13.62 (0.71)					14.20 (0.52)	13.47 (0.81)	14.12 (0.53)
19 Bigonial Br	11.73 (0.69)	10.72 (0.54)	10.86 (0.55)	11.91 (0.85)					11.94 (0.52)		
20 Ear to Ear Br	18.83 (0.81)	18.43 (0.93)									
21 Biocular Br	9.17 (0.49)	9.42 (0.53)	9.59 (0.44)	9.43 (0.41)					p 8.91 (0.43)		
22 Interpupillary Br	6.27 (0.36)	6.23 (0.39)	6.33 (0.36)	6.51 (0.28)					p 6.48 (0.33)		
23 Interocular Br	3.33 (0.28)	3.15 (0.28)	3.17 (0.25)	3.21 (0.29)					p 3.79 (0.33)		
24 Nose Breadth	3.54 (0.29)	3.42 (0.38)	3.33 (0.26)	3.54 (0.26)					p 3.73 (0.28)		
25 Lip Length	5.23 (0.37)	4.87 (0.44)	5.16 (0.36)	5.14 (0.43)					4.79 (0.39)		
26 Ear Protrusion	2.16 (0.34)	2.11 (0.37)	2.15 (0.36)	2.19 (0.35)							
27 Subnasale-Nasal Rt Lgth	5.13 (0.37)	5.10 (0.37)	5.09 (0.34)	5.34 (0.37)					pd†5.36 (0.39)	5.00 (0.47)	
28 Philtrum Lgth	1.55 (0.28)	1.47 (0.26)	1.94 (0.34)								
29 Lip to Lip Length	1.73 (0.38)	1.86 (0.40)	1.62 (0.31)	1.66 (0.36)							
30 Menton-Subnasale Lgth	6.90 (0.53)	7.01 (0.61)	6.67 (0.69)	7.02 (0.59)					pd 7.18 (0.50)	7.15 (0.53)	
31 Face Length	12.03 (0.61)	11.92 (0.68)							p 12.54 (0.62)		12.31 (0.64)
32 Glabella-Vertex	9.27 (0.97)	9.21 (0.81)							p 9.79 (0.71)		
33 Nasal Root-Vertex	10.75 (0.94)	10.84 (0.78)			10.25 (0.86)			10.63 (0.96)	p 11.33 (0.77)		
34 X-Canthus-Vertex	11.95 (0.77)				10.54 (0.89)				p 12.04 (0.62)		
35 Pronasale-Vertex	14.74 (1.10)	14.83 (0.87)									
36 Subnasale-Vertex	16.09 (1.02)								p 16.70 (0.76)		
37 Stomion-Vertex	18.37 (1.00)	18.23 (0.84)							p 18.92 (0.76)		
38 Menton-Vertex	22.77 (1.02)	22.67 (0.97)		22.18 (1.02)	22.34 (1.09)			22.95 (1.01)	p 23.87 (0.85)		
39 Tragion-Vertex	13.45 (0.61)		12.97 (0.75)	13.11 (0.64)	13.25 (0.74)			13.03 (0.64)	p 13.87 (0.53)	13.07 (0.89)	
40 Glabella to Wall	20.35 (0.67)	19.83 (0.71)									
41 Nasal Root to Wall	20.17 (0.66)	19.60 (0.70)	19.69 (0.86)	20.04 (0.69)					p 20.25 (0.60)		
42 X-Canthus to Wall	17.79 (0.66)	17.21 (0.74)	17.21 (0.79)	17.78 (0.70)					p 17.86 (0.57)		
43 Pronasale to Wall	22.68 (0.75)	21.98 (0.82)		22.85 (0.76)					p 22.58 (0.70)		
44 Subnasale to Wall	20.99 (0.79)	20.55 (0.91)							p 20.79 (0.71)		
45 Lip Prom to Wall	21.16 (0.86)										
46 Chin Prom to Wall	20.47 (1.05)				20.92 (1.13)			19.98 (1.07)	p 19.79 (0.88)		
47 Tragion to Wall	10.33 (0.65)	9.63 (0.68)	10.23 (0.75)	10.81 (0.76)	10.23 (0.84)			10.14 (0.69)	p 9.94 (0.57)		
48 Age	30.03 (6.31)	22.69 (6.49)	27.39 (4.22)		27.84 (7.23)			30.76 (6.49)			31.53 (8.17)
49 Height	177.34 (6.19)	175.28 (6.56)	175.56 (6.16)	177.64 (5.91)	176.95 (6.48)	176.80 (8.60)	176.60 (6.20)	177.00 (6.20)		175.99 (6.14)	175.05 (6.32)
50 Weight	173.60(21.44)	156.49(23.92)	163.44(20.82)	171.40(19.09)	165.99(19.40)	169.12(22.71)	158.32(17.42)	165.43(19.42)		167.56(20.43)	169.69(25.86)

*Age in years, weight in pounds, all others in cm.
**Measured from photographs.
†Derived from measurements made from photographs.

TABLE 2

DEVIATIONS OF SAMPLE MEAN VALUES FROM THE USAF 1967 MEAN VALUES

Variable Name*	1 1967 USAF n=2420	2 1965 USAF n=3869	3 1950 USAF n=4000	4 1964 U.S.Navy n=1549	5 1973 RNZAF n=238	6 1971 RAAF Aircrew n=385	7 1971 RAAF Cadets n=97	8 1971 RAF n=2000	9 1972 RAF Heads n=500	10 1962 RCAF n=604	11 1974 CF n=565
1 Head Circ	57.52	-1.26	-0.49	0.02	0.13	0.78	0.18	0.15	0.18	-0.24	0.23
2 Sagittal Arc	34.64	3.21	3.47	2.27							1.80
3 Min Frontal Arc	13.60	-1.63	0.07						-0.39		
4 Bit-Coronal Arc	35.76	-0.68	-0.71	-0.24	0.92			-0.42	0.37		-0.35
5 Bit-Min Front Arc	30.81	-0.33	-0.33	-0.61					0.50		
6 Bit-Subnasal Arc	29.31	-0.61	-0.33	-0.63					-0.19		
7 Bit-Menton Arc	32.65	-1.24	-0.32	-0.44					-0.25		
8 Bit-Submandibular Arc	30.98	-1.69	-0.36	0.24					-1.20		
9 Bit-Posterior Arc	29.45		-0.08	1.99					-1.96		
10 Head Length	19.87	-0.25	-0.17	-0.04	-0.16			0.03	p** 0.66	-0.51	
11 Head Diag from Menton	25.60	-0.45			-0.29			0.61	0.27		
12 Ear Breadth	3.80	-0.28	-0.14	-0.23							
13 Ear Length	6.60	-0.26	-0.33	-0.07							
14 Ear Lgth above Tragion	2.94	-0.07	0.03								
15 Head Breadth	15.60	-0.29	-0.19	-0.03	-0.39	0.10	-0.10	0.18	p 0.74	-0.31	
16 Max Frontal Br	11.60	-0.14	0.36	0.66					-0.41		
17 Bitragion Br	14.25	-0.42	-0.03	-0.26	-0.57			-0.34	-0.49		
18 Face Breadth	14.23	-0.24	-0.14	-0.61					-0.03	-0.76	-0.13
19 Bigonial Br	11.73	-0.01	-0.87	0.18					0.21		
20 Ear to Ear Br	18.83	-0.40									
21 Biocular Br	9.17	0.25	0.42	0.26					-0.26		
22 Interpupillary Br	6.27	-0.04	0.06	0.24					p 0.21		
23 Interocular Br	3.33	-0.18	-0.16	-0.12					p 0.46		
24 Nose Breadth	3.54	-0.12	-0.21	0.0					p 0.19		
25 Lip Length	5.23	-0.36	-0.07	-0.09					-0.44		
26 Ear Protrusion	2.16	-0.05	-0.01	0.03							
27 Subnasale-Nasal Rt Lgth	5.13	-0.03	-0.04	0.21					0.23	-0.13	
28 Philtrum Length	1.55	-0.08	0.39								
29 Lip to Lip Length	1.73	0.13	-0.11	-0.07							
30 Menton-Subnasale Lgth	6.90	0.11	-0.23	0.12					pd† 0.28		
31 Face Length	12.03	-0.11							p 0.51		0.28
32 Glabella-Vertex	9.27	-0.06							p 0.52		
33 Nasal Rt-Vertex	10.75	0.09			-0.50			-0.12	p 0.58		
34 X-Canthus-Vertex	11.95				-1.41				p 0.09		
35 Pronasale-Vertex	14.74	0.09									
36 Subnasale-Vertex	16.09								p 0.61		
37 Stomion-Vertex	18.37	-0.14							p 0.55		
38 Menton-Vertex	22.77	-0.10		-0.59	-0.43			0.18	p 1.10		
39 Tragion-Vertex	13.45		-0.48	-0.34	-0.20			-0.42	p 0.42	-0.38	
40 Glabella to Wall	20.35	-0.52									
41 Nasal Rt to Wall	20.17	-0.57	-0.48	-0.13					p 0.08		
42 X-Canthus to Wall	17.79	-0.58	-0.58	-0.01					p 0.07		
43 Pronasale to Wall	22.68	-0.70		0.17					p -0.10		
44 Subnasale to Wall	20.99	-0.44							p -0.20		
45 Lip Prom to Wall	21.16										
46 Chin Prom to Wall	20.47				0.45			-0.49	p -0.68		
47 Tragion to Wall	10.33	-0.70	-0.10	0.48	-0.10			-0.19	p -0.39		
48 Age	30.03	-7.34	-2.64		-2.19			0.73			1.50
49 Height	177.34	-2.06	-1.78	0.30	-0.39	-0.54	-0.74	-0.34		-0.97	-2.29
50 Weight	173.60	-17.11	-10.16	-2.20	-7.61	-4.48	-15.28	-8.17		-6.04	-3.91

*Age in years, weight in pounds, and all others in cm.
**Measured from photographs.
†Derived from measurements made from photographs.

Delta values must be approached with caution since they do not always reflect actual deviations between comparable samples; rather, they can often be the result of anomalies inherent in the data-gathering process. Among the common problems of anthropometric comparison are (1) variability in measuring techniques and/or landmarks used by different anthropometrists and (2) the variability in the composition (age, stature, weight, ethnic background, etc.) of the different populations surveyed.

It is obvious from some of the delta values in Table 2 that despite the similarity of variable names, different techniques/landmarks may have been employed. We see, for example, that Minimum Frontal Arc (Variable 3) for the USAF 1965 sample is 12% less than the USAF 1967 value, raising the strong possibility that different forehead landmarks were used for the measurement. Deviations of this magnitude strongly suggest differences in landmark interpretation, especially when viewed in conjunction with the fact that for the same two samples the differences in Bitragion-Minimum Frontal Arc (Variable 5) are only 1%.

Further evidence that some variations in data are caused by differences in measuring techniques can be seen by studying Figures 1-3 in which the means, plus/or/minus two standard deviations, are plotted for three variables: head circumference (Figure 1), head length (Figure 2), and head breadth (Figure 3). The area between the dotted lines represents the plus/or/minus two standard deviations (95%) variance for the 1967 USAF sample. It will be noted that the head circumference for the RAF 1971 Survey and the RAF Head Survey are essentially identical (Figure 1), whereas the head length (Figure 2) and head breadth means (Figure 3) of the RAF head study are approximately a standard deviation larger than the comparable dimensions of the RAF 1971 study. As noted above, in the RAF head study head circumference was measured in the traditional manner while the latter two variables were measured from photographs.

A second course of artifactual variability in comparing anthropometric head data from different surveys is the possible difference in age and general body size of the subject populations. One means of demonstrating this kind of difference is to examine a survey in which one can assume that the measurement techniques are comparable throughout and compare the head data for specific subsets within that survey population. The USAF 1965 survey, for example, contained a number of subsets and selected head measurements from three such groups and are shown in the following table.

TABLE 3

USAF 1965 SUBSETS--MEAN VALUE OF SELECTED VARIABLES *

n	Subset	Age	Stature	Weight	Head Circ	Head Length	Head Breadth
2527	Basic Trainees	18.82	175.07	68.73	55.88	19.53	15.21
792	Enlisted	26.01	174.72	73.46	56.64	19.69	15.40
549	Officers	32.09	177.10	77.77	57.47	19.95	15.66

* Age in years, weight in kilograms, all other values in centimeters.

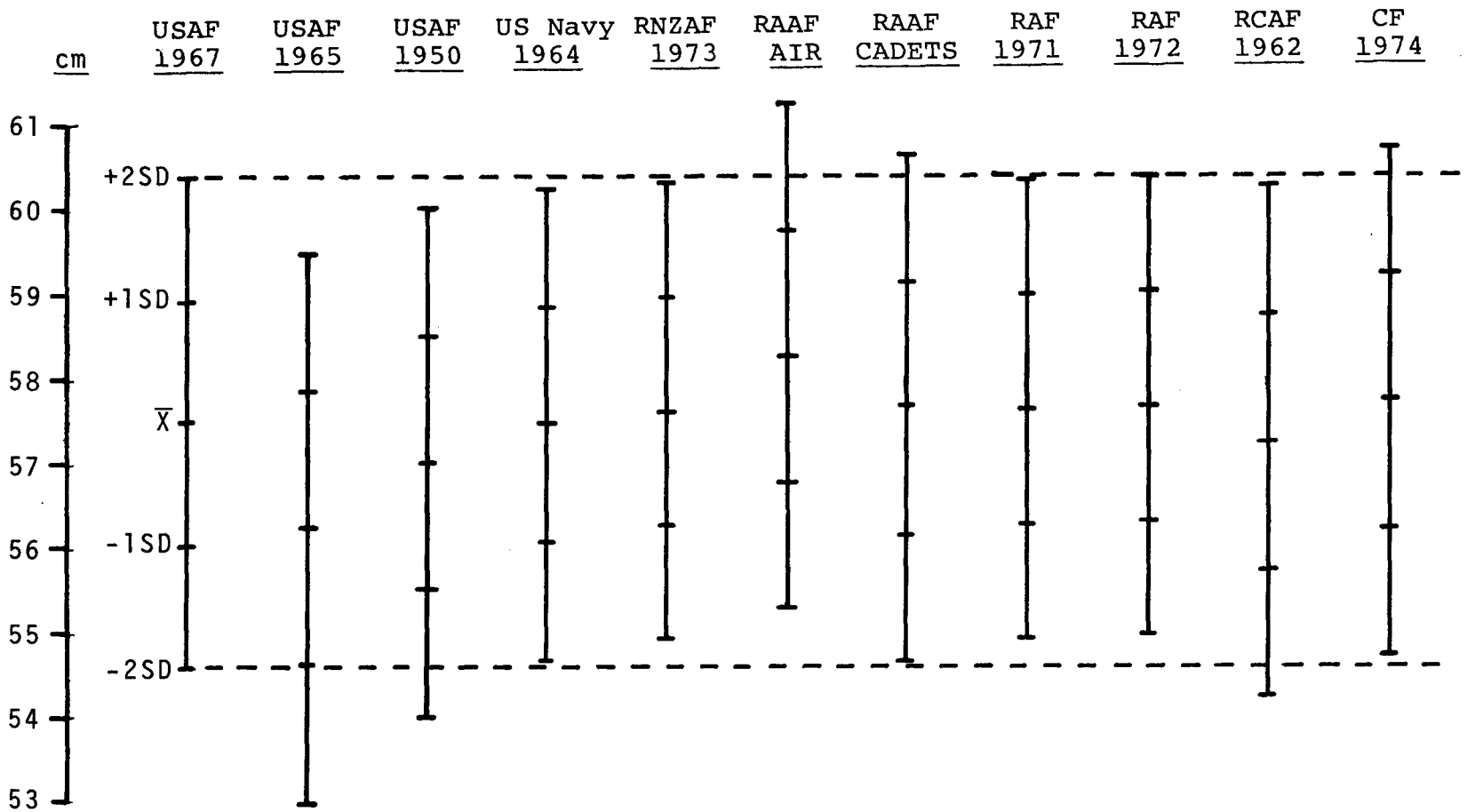


Figure 1. Head circumference.

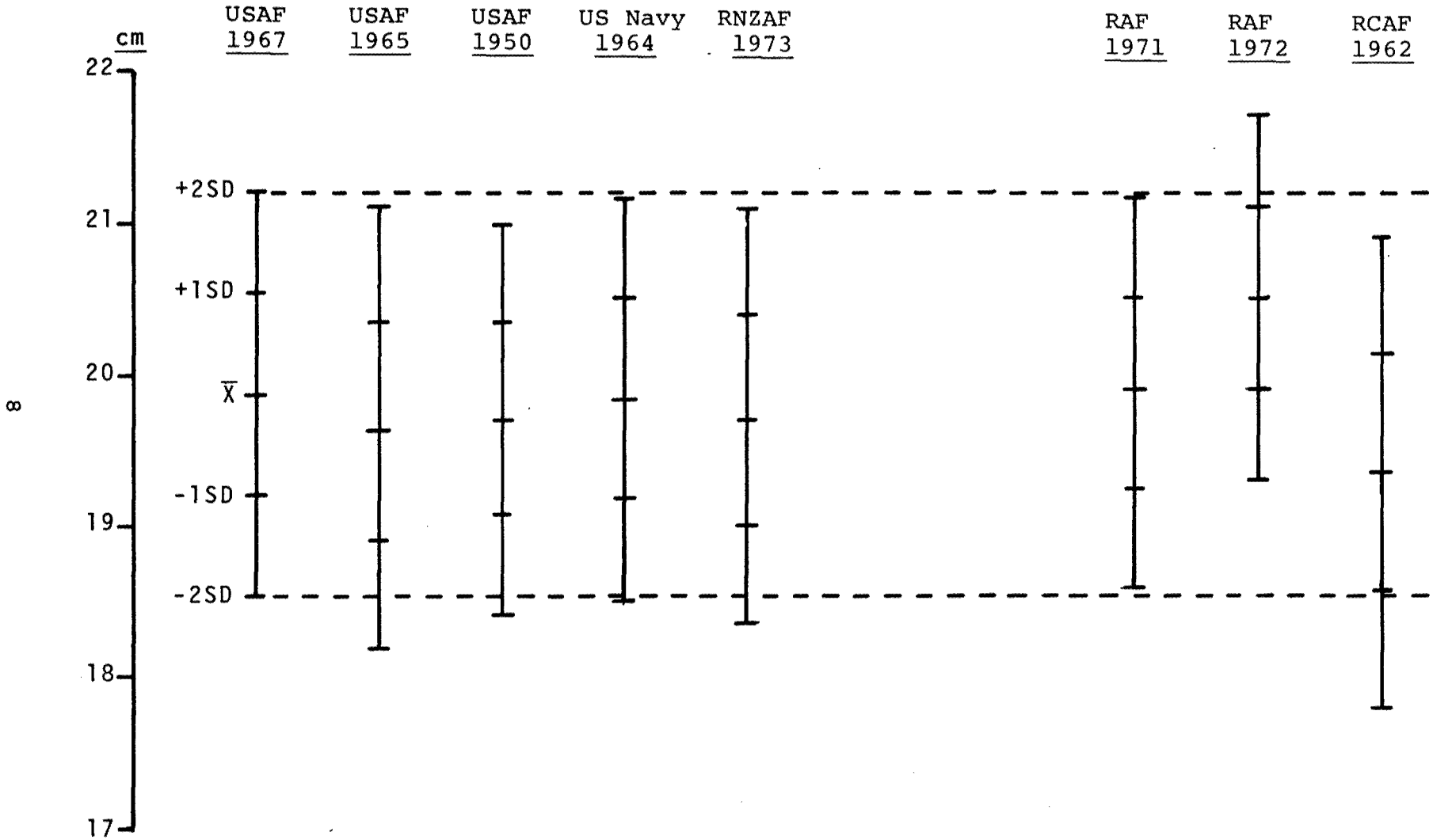


Figure 2. Head length.

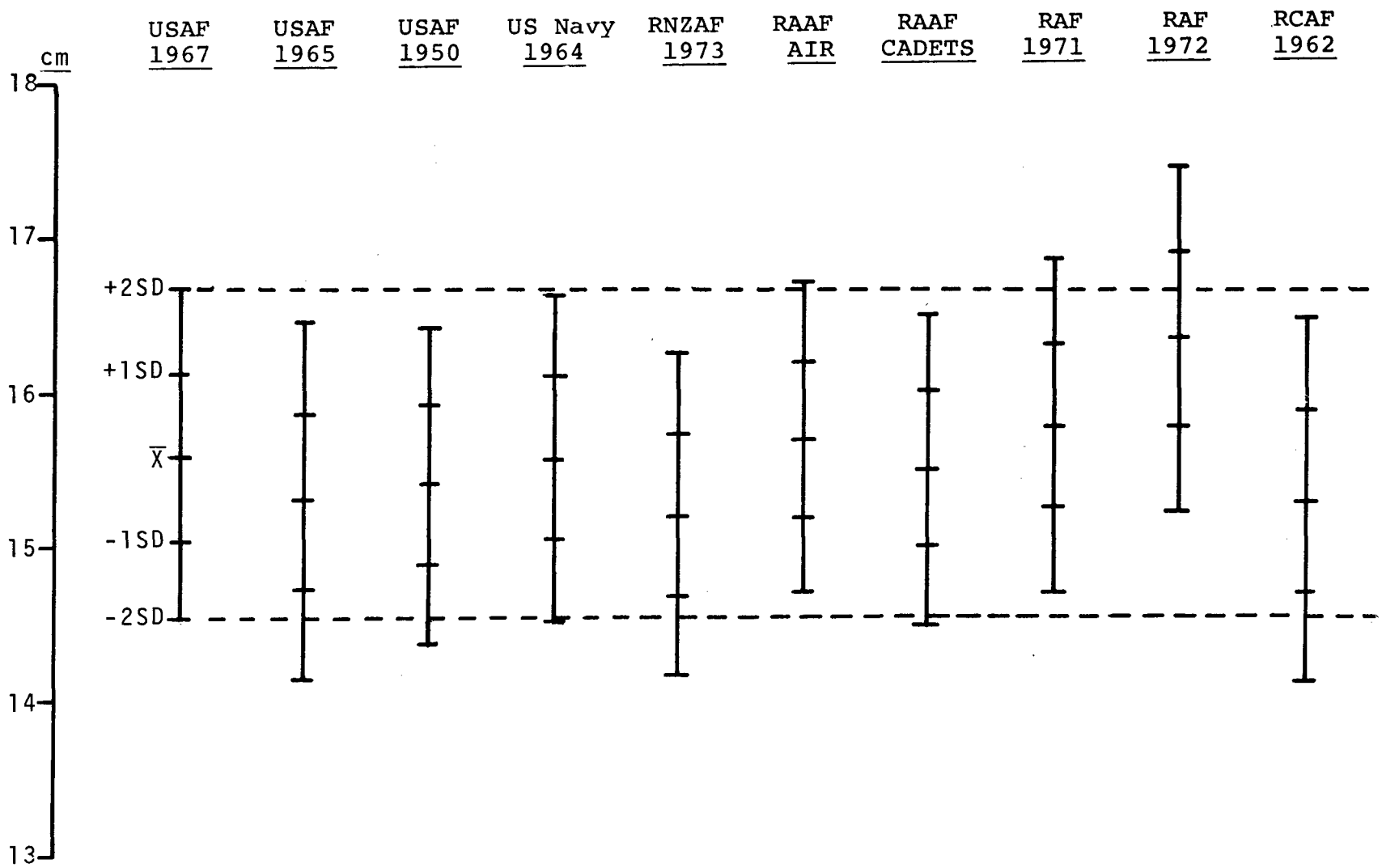


Figure 3. Head breadth.

As can be observed, the range of age, stature and weight is considerable. Correspondingly, the range of the head measurements is also of noticeable magnitude. The range of subgroups means from smallest to largest delta for head circumference is 1.59 cm; for head length, 0.42 cm; and for head breadth, 0.45 cm. This level of variance approaches that for the samples tabulated in Table 1, as can be seen in the following comparison.

TABLE 4

INTER-POPULATION VARIATION VS. INTRA-POPULATION VARIATION FOR SELECTED HEAD VARIABLES

	Head Circ Δ Means	Head Length Δ Means	Head Breadth Δ Means
Selected subsets, 1965 Survey	1.59 cm	0.42 cm	0.45 cm
Eleven surveys cited in Table 1*	2.04 cm	0.54 cm	0.57 cm

What is apparent from these comparisons is that the differences in head dimensions between the various ASCC groups are relatively small when viewed against the range of variability within any single sample. With this factor in mind, it is of some interest to determine how well design criteria developed by one ASCC nation might accommodate service personnel from other ASCC nations.

Test of Anthropometric Comparability: There is not, unfortunately, a great deal of published material on recommended anthropometric design criteria for helmet sizing. The recent publication by Simpson, Specimen Size Rolls for Aircrew Headgear Based on an Analysis of the Head Measurements of 2000 RAF Air Crew, contains a six-size head circumference sizing program similar to the one recommended by Zeigen for the USAF in 1960. The American program has been widely used and the head forms developed as a part of this program are accepted as a standard by many military and industrial designers in the United States. The key or sizing variable, head circumference, was not broken out into comparable head-size categories in the two sizing programs so, in order to make a comparison possible, the USAF 1967 data were reanalyzed to correspond to the six sizing categories recommended in the RAF program. The results of this comparison are shown in Table 5. The table lists in columns the difference (Δ) in centimeters (USAF size category mean minus RAF size category mean), the average difference for the six size categories, disregarding sign ($|\overline{\Delta}|$), and this difference as a percent of the RAF mean value $\left(\frac{|\overline{\Delta}|}{\overline{x}}\right)$. The first

*The 1972 RAF head data, measured from photographs, were excluded from the computation because the variance in the results would have unnecessarily skewed the results.

TABLE 5

DEVIATIONS OF SIZING MEANS BETWEEN USAF AND RAF ANTHROPOMETRY COMPARED IN AN RAF SIX-SIZE HEAD CIRCUMFERENCE SIZING SYSTEM

HEAD CIRC RANGE (cm)	Size 1 53.6-54.9	Size 2 55.0-56.3	Size 3 56.4-57.7	Size 4 57.8-59.1	Size 5 59.2-60.5	Size 6 60.6-62.0	$\overline{\lvert\Delta\rvert}$	$\frac{\overline{\lvert\Delta\rvert}}{\bar{x}}$
TARIFF Δ%	+1.08	+3.65	-0.38	-3.30	-0.95	-0.11	1.58	-
Head Breadth Δ cm*	0.06	-0.09	-0.16	-0.17	-0.17	-0.24	0.15	0.95%
Head Length	0.03	0.03	0.03	0.01	0.04	0.24	0.06	0.30
Head Circ	-0.05	0.01	0.02	-0.01	0.01	0.11	0.04	0.07
Bitrag-Coronal Arc	0.71	0.43	0.49	0.48	0.59	0.67	0.56	1.58
Bitragion Breadth	0.33	0.40	0.36	0.37	0.34	0.25	0.34	2.44
Max Diag from Menton	-0.46	-0.55	-0.51	-0.61	-0.59	-0.55	0.55	2.10
Menton to Wall	0.52	0.64	0.53	0.52	0.49	0.84	0.59	2.95
Menton to Vertex	-0.06	-0.24	-0.29	-0.15	-0.08	-0.33	0.16	0.70
Tragion to Wall	0.38	0.29	0.18	0.23	0.16	0.34	0.26	2.56
Tragion to Vertex	0.55	0.41	0.41	0.45	0.58	0.33	0.46	3.53
Nasion to Vertex	0.12	0.03	0.12	0.12	0.35	0.23	0.16	1.51
Nasion to Menton	-0.25	-0.28	-0.22	-0.27	-0.34	-0.52	0.31	2.52

* USAF 1967 size subgroup mean value minus RAF size subgroup mean value.

row of the table shows the difference in tariffs for the two samples. The tariffs (ratio of number of subjects in the sizing category subgroup to total sample size) range in absolute difference from a minimum of 0.11 (Size 6) to a maximum of 3.65 (Size 2) with an average absolute deviation of 1.56% and includes 100% of the RAF sample and 99.75% of the USAF 1967 sample. This suggests that the head circumference distributions of the two samples were very similar, a conclusion reinforced by comparison of the mean head circumferences of the six subgroups. Scanning across the table, it can be seen that the differences in head circumference range from 0.01 to 0.11 cm with the average absolute difference of the six being 0.04 cm. The variables of head length and head breadth also show a very low order of difference as would be expected due to their rather strong relationship with head circumference. The remaining variables show a greater level of difference due, in part, to possible differences in measuring techniques but also partly due to the generally low level of relationship between most of the dimensions of the head and face. What this means, of course, is that by control of a key or sizing dimension, such as head circumference, we effectively control its variance and that of the dimensions most highly correlated with it but exert modest control of the variance of the other head and face dimensions. The standard deviations of the dimensions listed in Table 5 for each of the six sizing category subgroups were found to be virtually identical in most instances. This would mean that helmet design dimensions based on category means and standard deviations would be essentially the same for the two populations.

Conclusions. It appears, therefore, that helmets or other headgear which are successfully fitted for a member nation's flying personnel could be fitted with equal success to the flying personnel of other ASCC nations.

One final note: if anthropometric surveys are to be used for comparative purposes, it is of singular importance that anthropometric techniques be standardized or, if that is not possible, that measuring techniques be fully reported so as to facilitate assessment of their comparability.

REFERENCES

Anonymous. RAAF Anthropometry Survey. Report No. TS 1614, Royal Australian Air Force, Aircraft Research and Development Unit, Laverton, Australia, 1973.

Anonymous. RCAF Anthropometrical Survey. Defense Documentation Center, Defense Supply Agency, Cameron Station, Alexandria, Virginia, 1961-62. (AD 809424)

Bolton, C. B., M. Kenward, R. E. Simpson, and G. M. Turner. An Anthropometric Survey of 2000 Royal Air Force Aircrew 1970/1971. TR 73083, Royal Aircraft Establishment, Farnborough, Hants, England, 1973. (AD 917048)

Gifford, Edmund C., Joseph R. Provost, and John Lazo. Anthropometry of Naval Aviators - 1964. NAEC-ACEL-533, Naval Air Engineering Center, Department of the Navy, Philadelphia, Pennsylvania, 1965. (AD 626322)

Grunhofer, H. J., and G. Kroh (eds.). A Review of Anthropometric Data of German Air Force and United States Air Force Flying Personnel 1967-1968. AGARDograph No. 205, AGARD, Neuilly Sur Seine, France, 1975. (N75 26635)

Hertzberg, H. T. E., G. S. Daniels, and Edmund Churchill. Anthropometry of Flying Personnel - 1950. WADC TR 52-321, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, 1954. (AD 47953)

Hobbs, P. C. An Anthropometric Survey of 500 Royal Air Force Aircrew Heads, 1972. TR 73137, Royal Aircraft Establishment, Farnborough, Hants, England, 1973. (AD 917599)

McCann, C., I. Noy, B. Rodden, and O. Logan. 1974 Anthropometric Survey of Canadian Forces Personnel. DCIEM Report No. 75-R-1114, Defence and Civil Institute of Environmental Medicine, Downsview, Ontario, 1975.

Simpson, R. E. Specimen Size Rolls for Aircrew Headgear Based on an Analysis of the Head Measurements of 2000 Royal Air Force Aircrew. Technical Report 74072, Royal Aircraft Establishment, Farnborough, Hants, England, 1974.

Toulson, P. K. Report on the Anthropometric Survey of RNZAF Aircrew. Report No. AMU 3/74, Royal New Zealand Air Force, Auckland, New Zealand, 1974.

U. S. Air Force. Anthropometric Survey of U. S. Air Force - 1965. Unpublished data of Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio

Zeigen, Robert S., Milton Alexander, and Edmund Churchill. A Head Circumference Sizing System for Helmet Design. WADD TR 60-631, Wright Air Development Division, Wright-Patterson Air Force Base, Ohio, 1960. (AD 251939)

☆U.S.Government Printing Office: 1978 — 757-080/329